Searching for Extra-Solar Bursts of Decameter Radiation

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Motivations for Decameter Astronomy

- There are numerous, well-studied sources of decameter radiation from within the solar system (Sun, Jupiter, etc.).
- However, no discrete extra-solar source of decameter radiation has ever been observed.

Gamma-Ray Bursts (GRB)

- Theorized to emit observable decameter radiation
- Could be used to probe GRB processes and directly measure the intergalactic medium

Sagittarius A*

- Previously observed to emit bursts at higher frequencies
- Could be used to observe its interactions with surrounding objects and other material

Decameter Astronomy from the Moon

Problems with Earth

- Interference from artificial sources (e.g., broadcasts)
- Interference from natural atmospheric activity
- Ionospheric distortions (plasma frequency ~ 30 MHz)

Advantages of the Moon

- No local radio sources
- Shielding from terrestrial interference
- No ionosphere

Question: What can be done with existing equipment *in lieu* of and in preparation for a decameter observatory on the Moon?

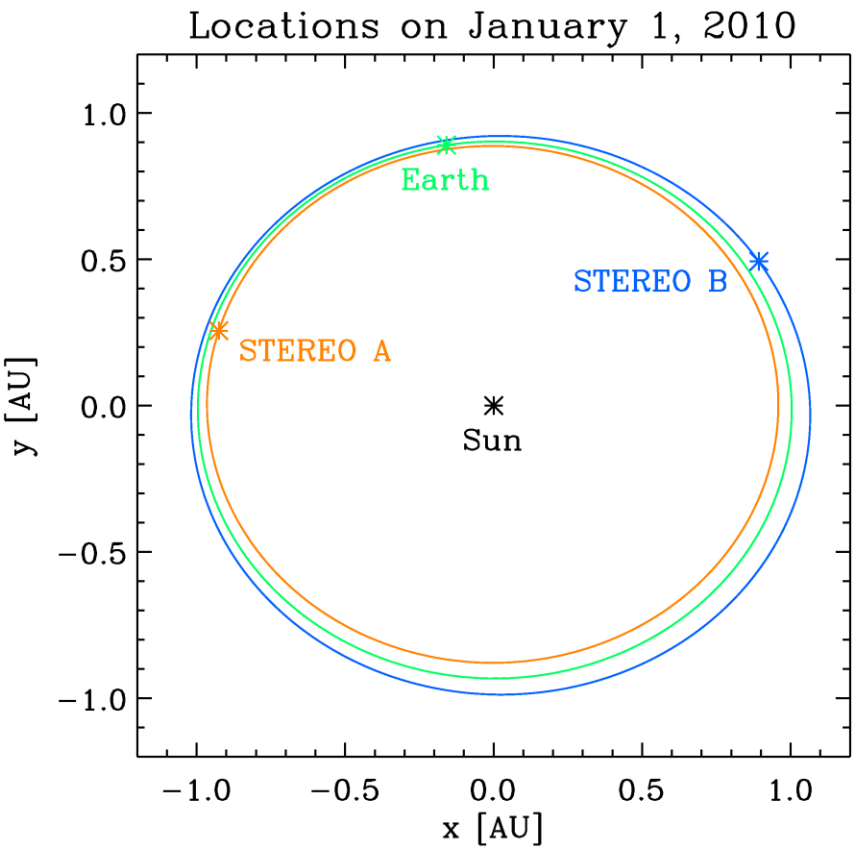
Outline

Goal: To use radio data from the STEREO spacecraft to explore the future of space-based decameter radio astronomy.

- Overview of the STEREO spacecraft
  - Spacecraft orbits
  - The WAVES instrument (low-frequency radio)
- Identifying potential sources of radio bursts from signal delays
- Events observed with STEREO/WAVES
  - Solar radio bursts
  - Jovian radio bursts
- Ongoing research

STEREO Spacecraft

- Launch date: October 26, 2006
- Two identical satellites
  - STEREO A (“Ahead”)
  - STEREO B (“Behind”)
- STEREO/WAVES instrument
  - Antennas: 3 orthogonal monopoles
  - Frequency range: 0.1 to 16 MHz
  - Frequency channels: 319
  - Sweep duration: 38.8 s



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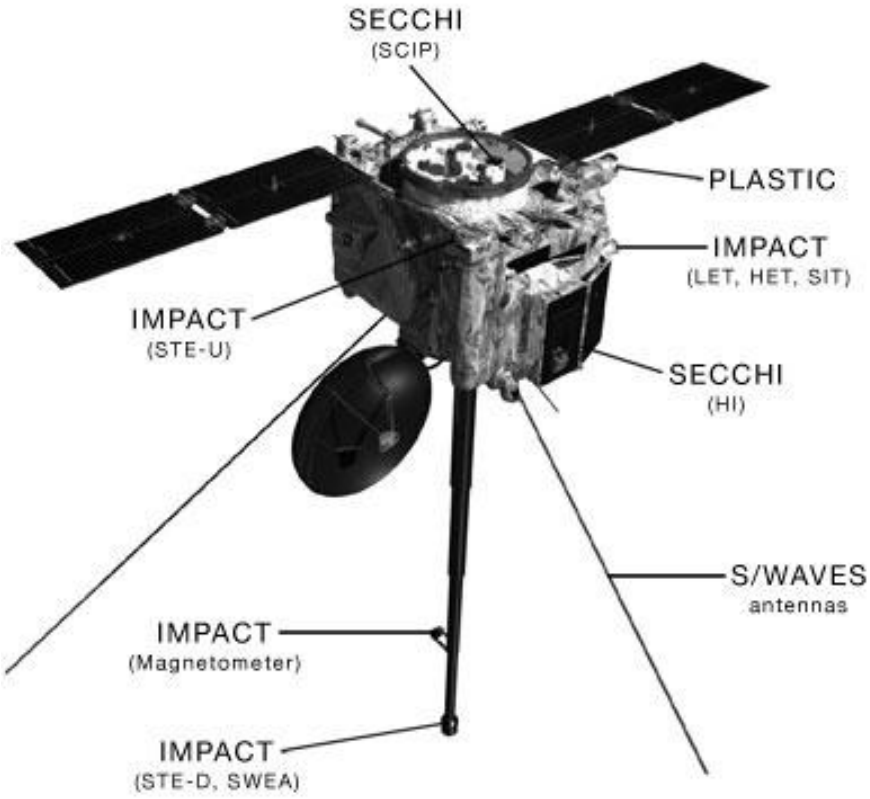
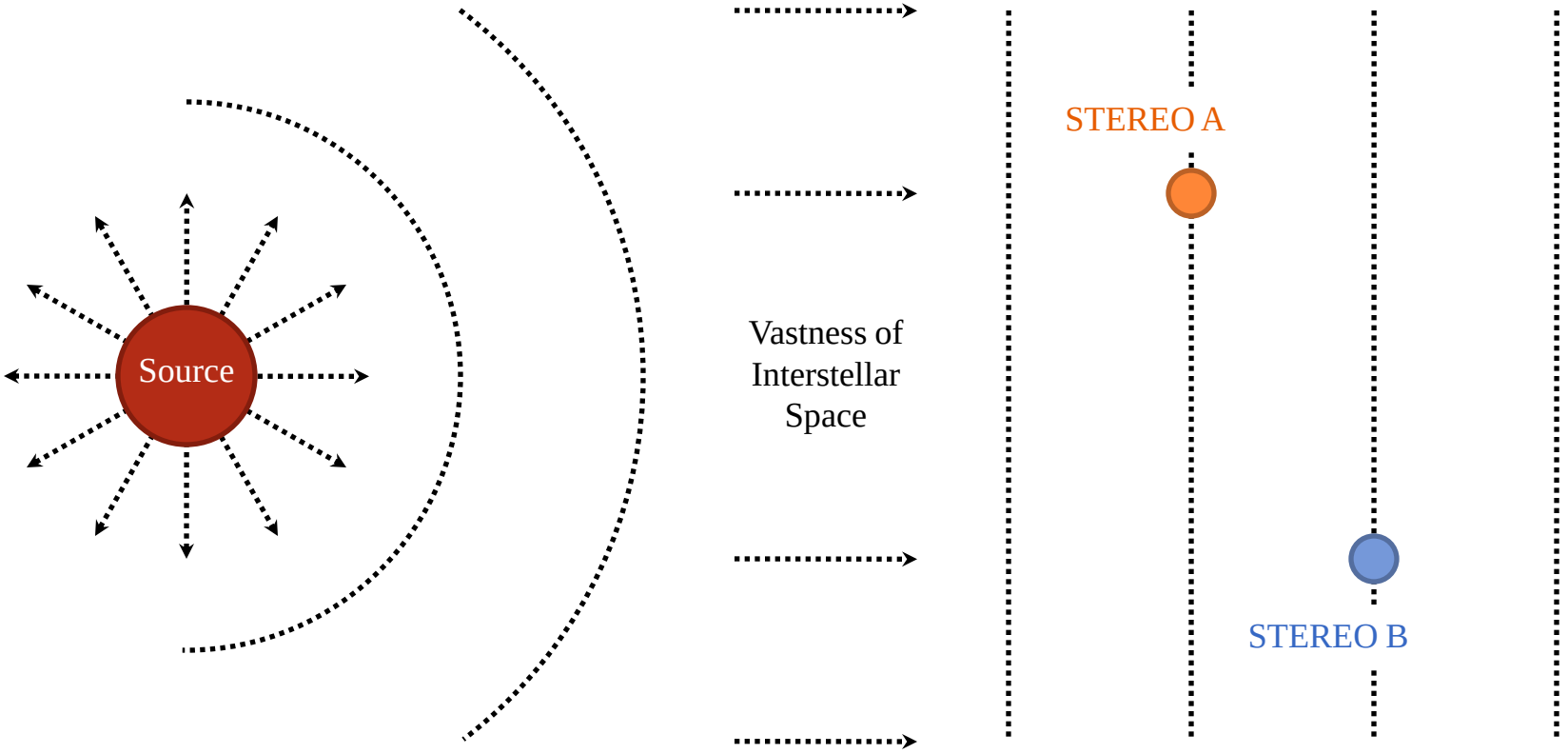


Delays in Signals from Extra-Solar ("Far-Field") Sources



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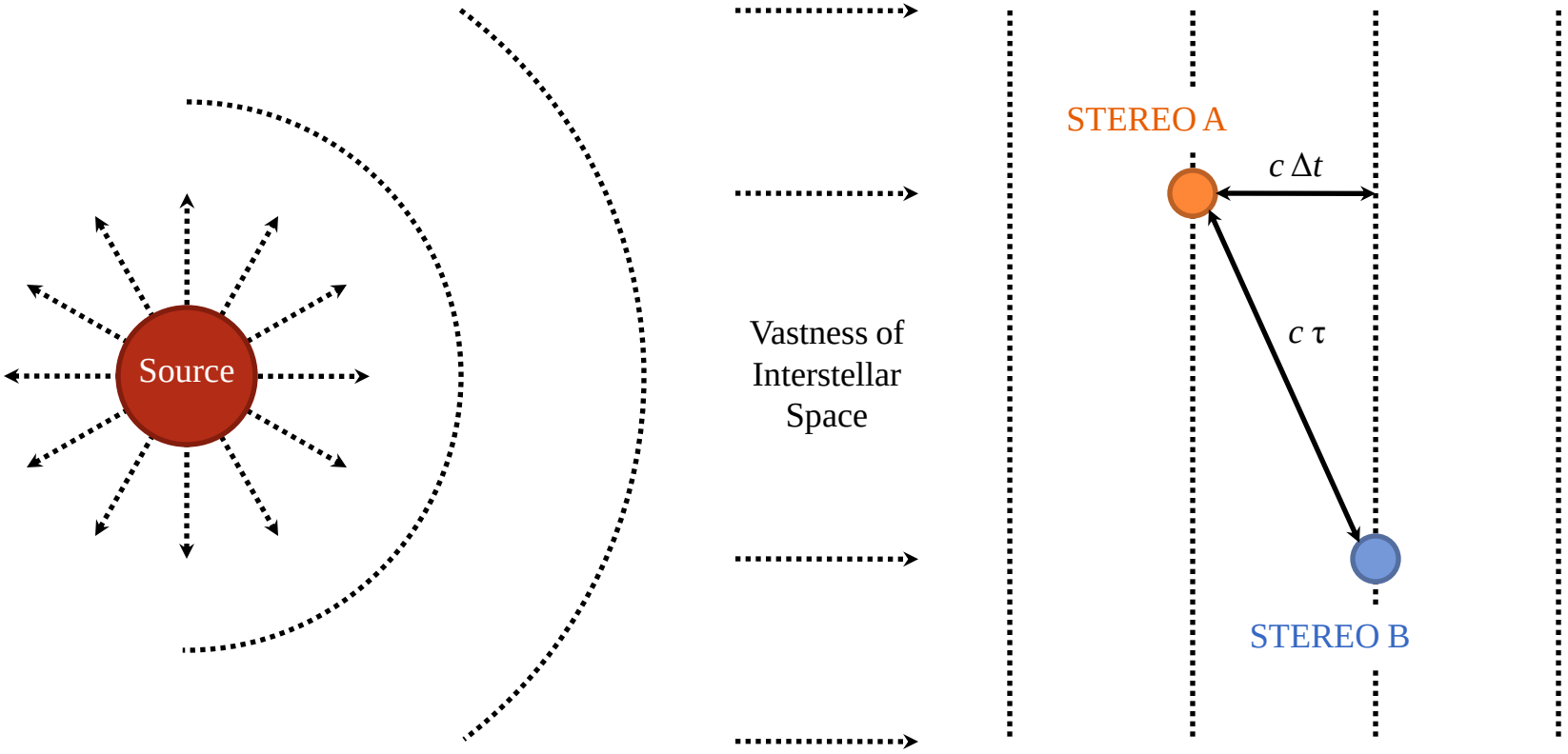
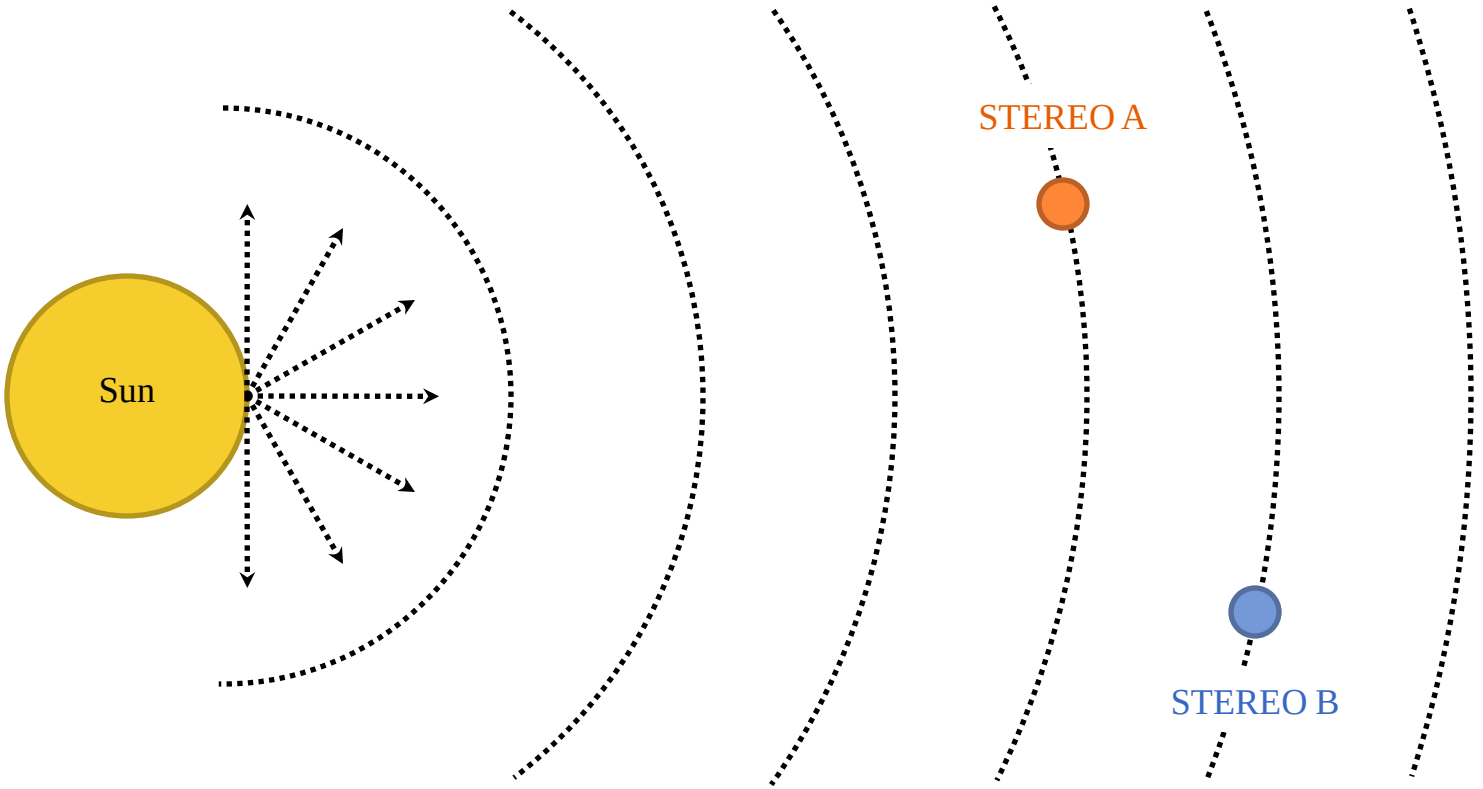


Delays in Signals from Solar System Sources



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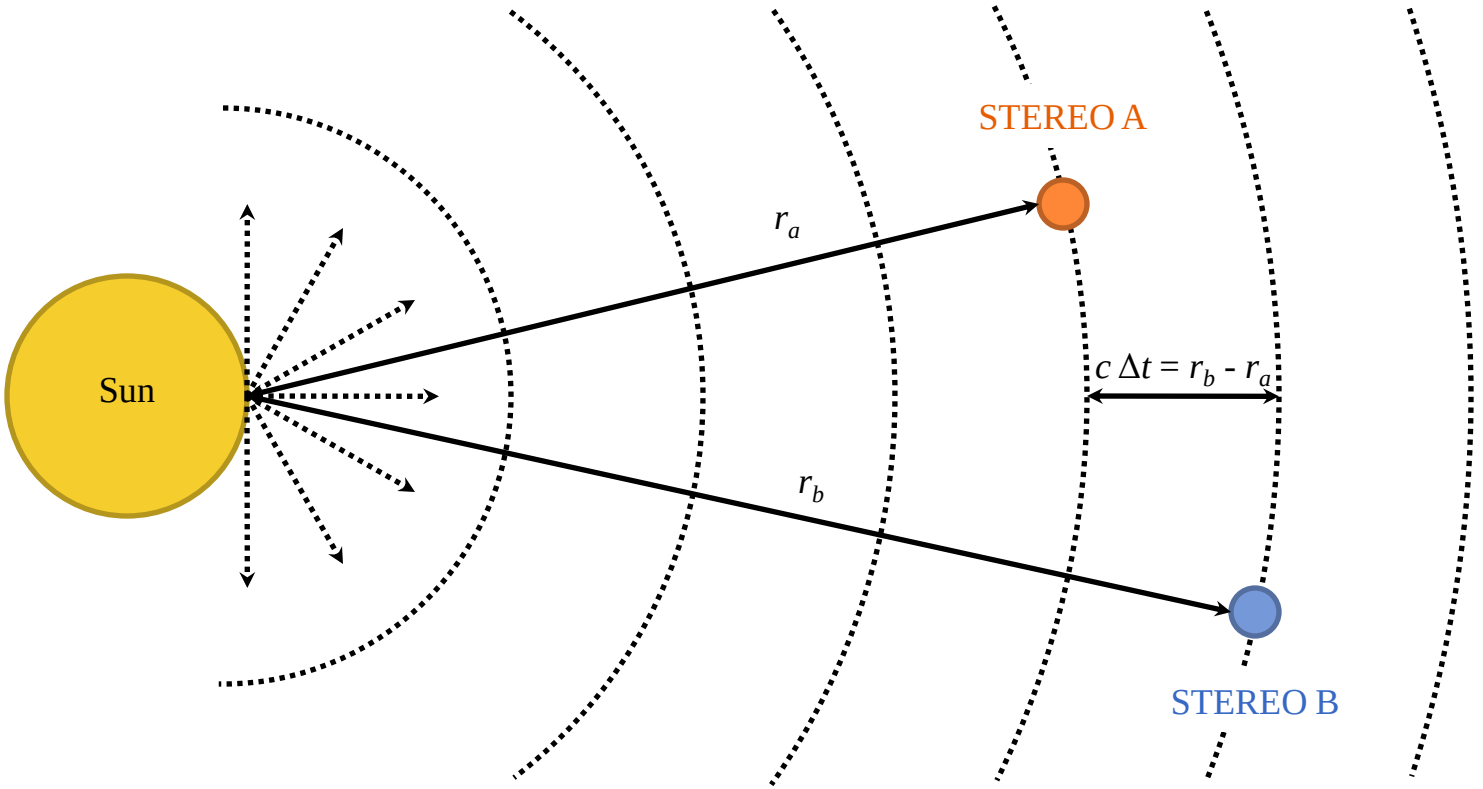
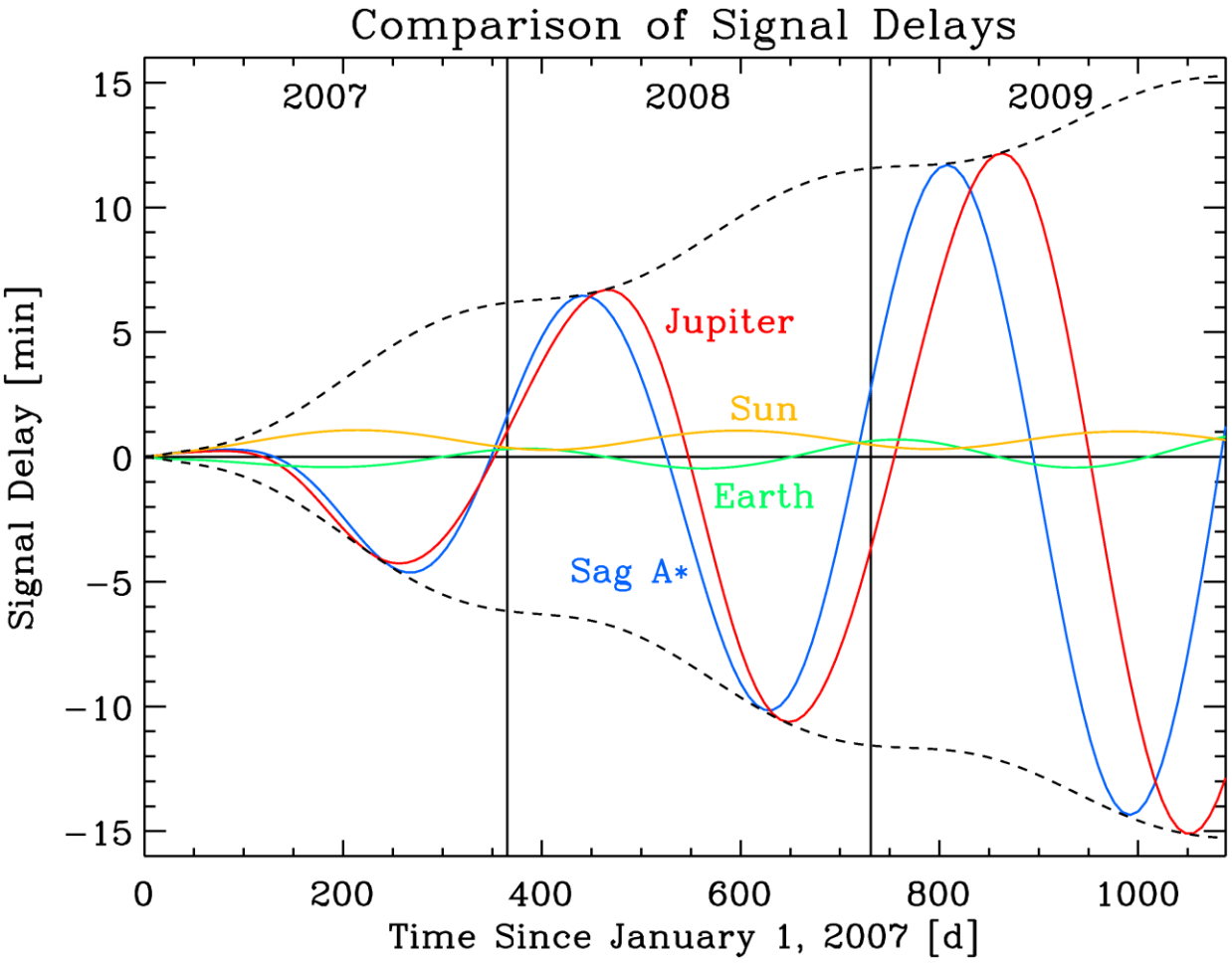
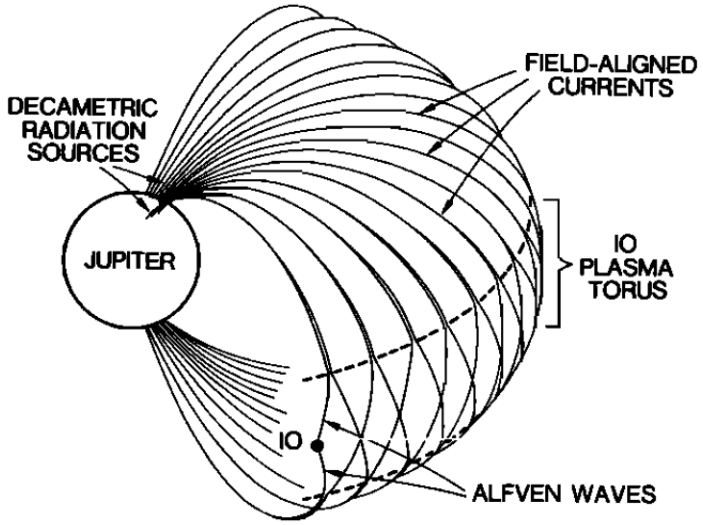
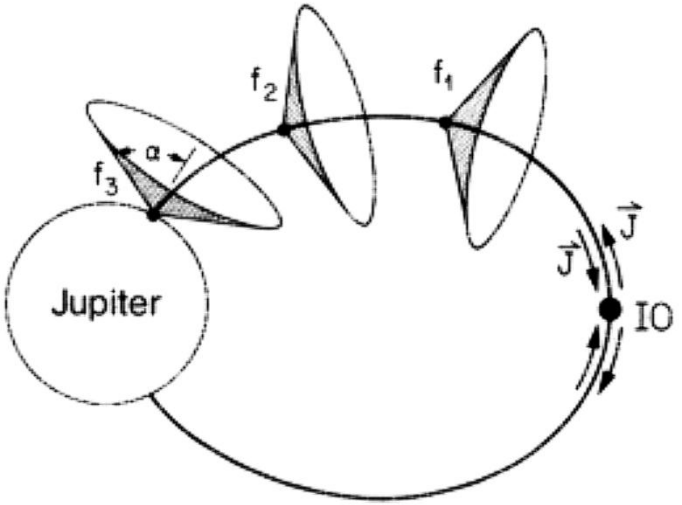


Signal Delays for STEREO Spacecraft



Delays in Signals from the Jupiter-Io System





- Beamed radiation from the Jupiter-Io system
- Factors controlling observability
  - Io's orbital phase
  - Orientation of Jupiter's magnetic axis

Gurnett and Goertz, 1981

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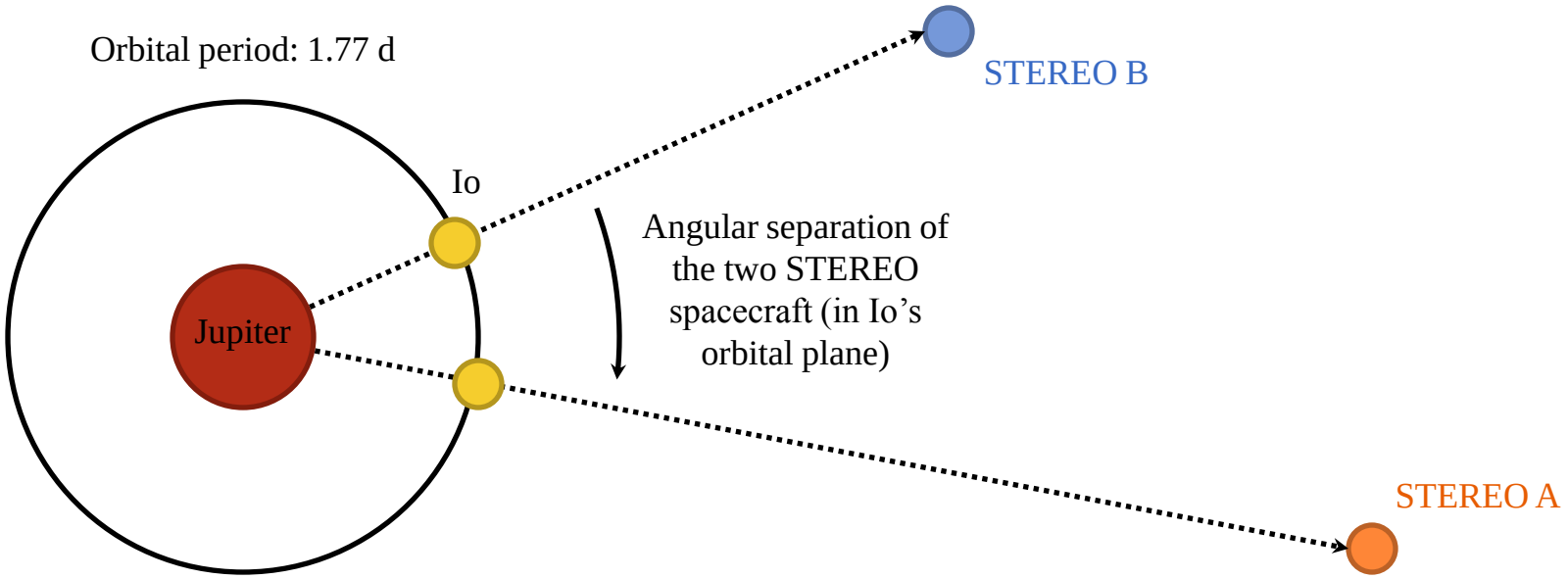

- Factors affecting arrival of signals at STEREO spacecraft
  - Distances of spacecraft from Jupiter
  - Angular separation of spacecraft in Io's orbital plane

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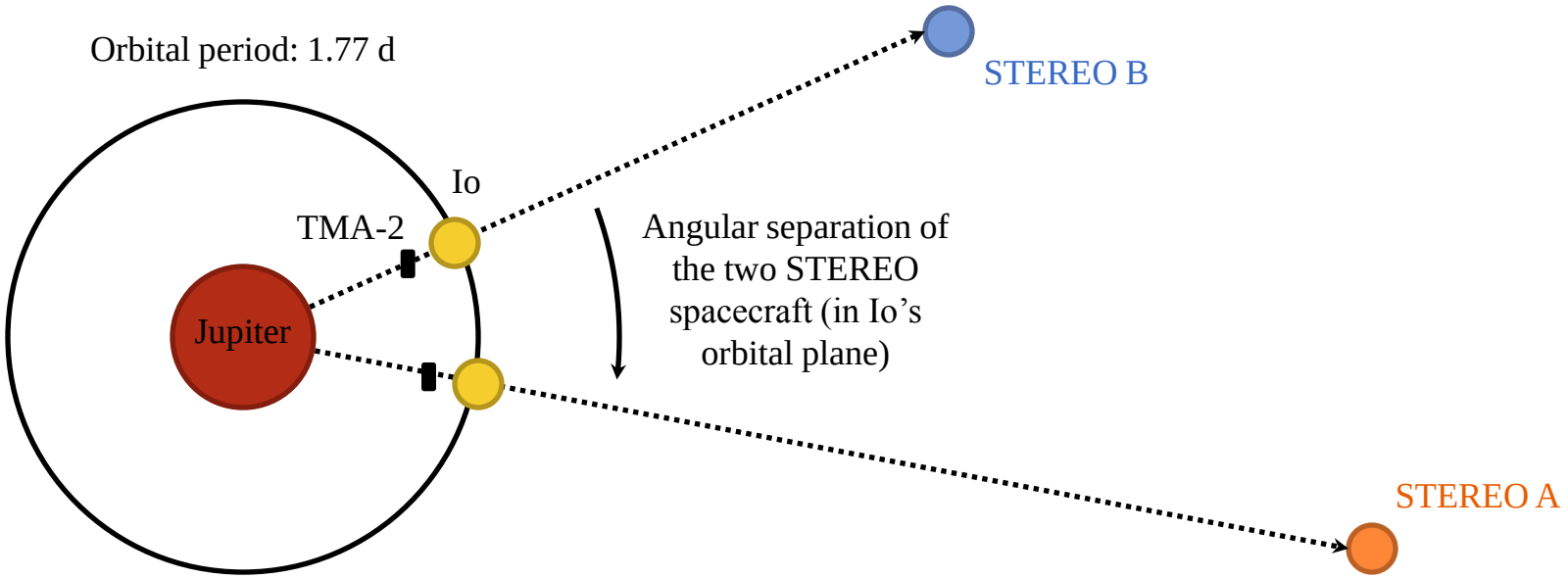

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Clarke, 2010: Odyssey Two, 1982

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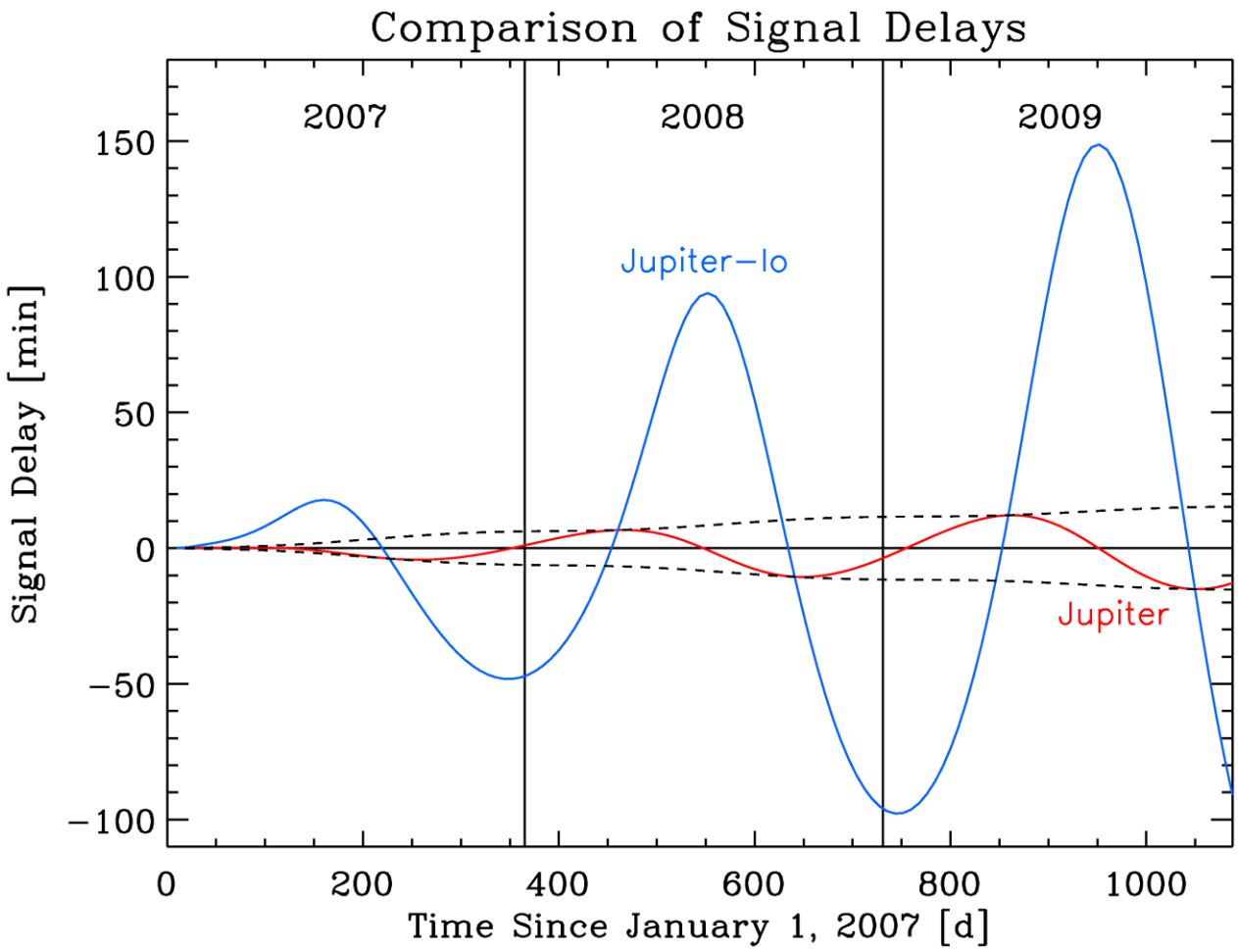
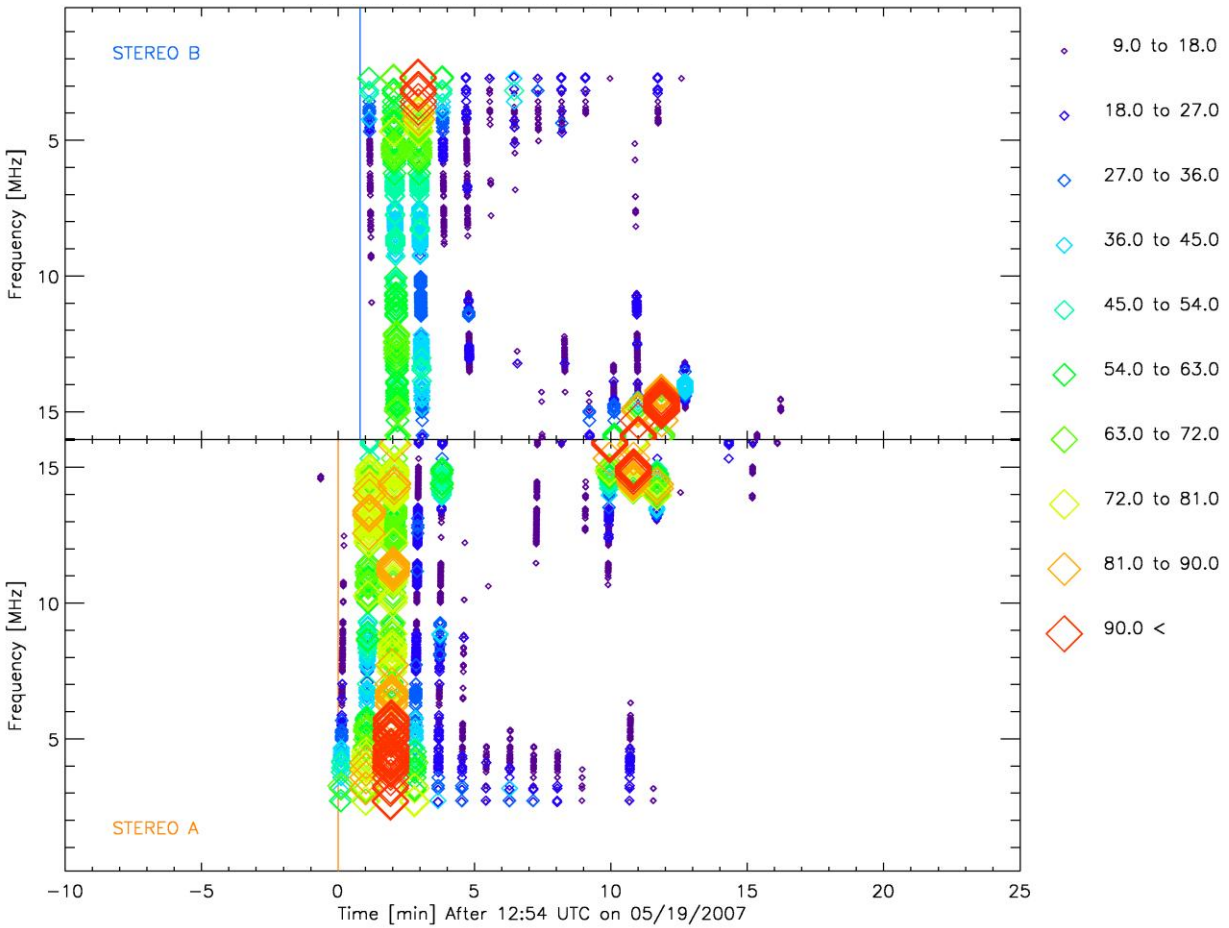


Solar Burst (Type III)



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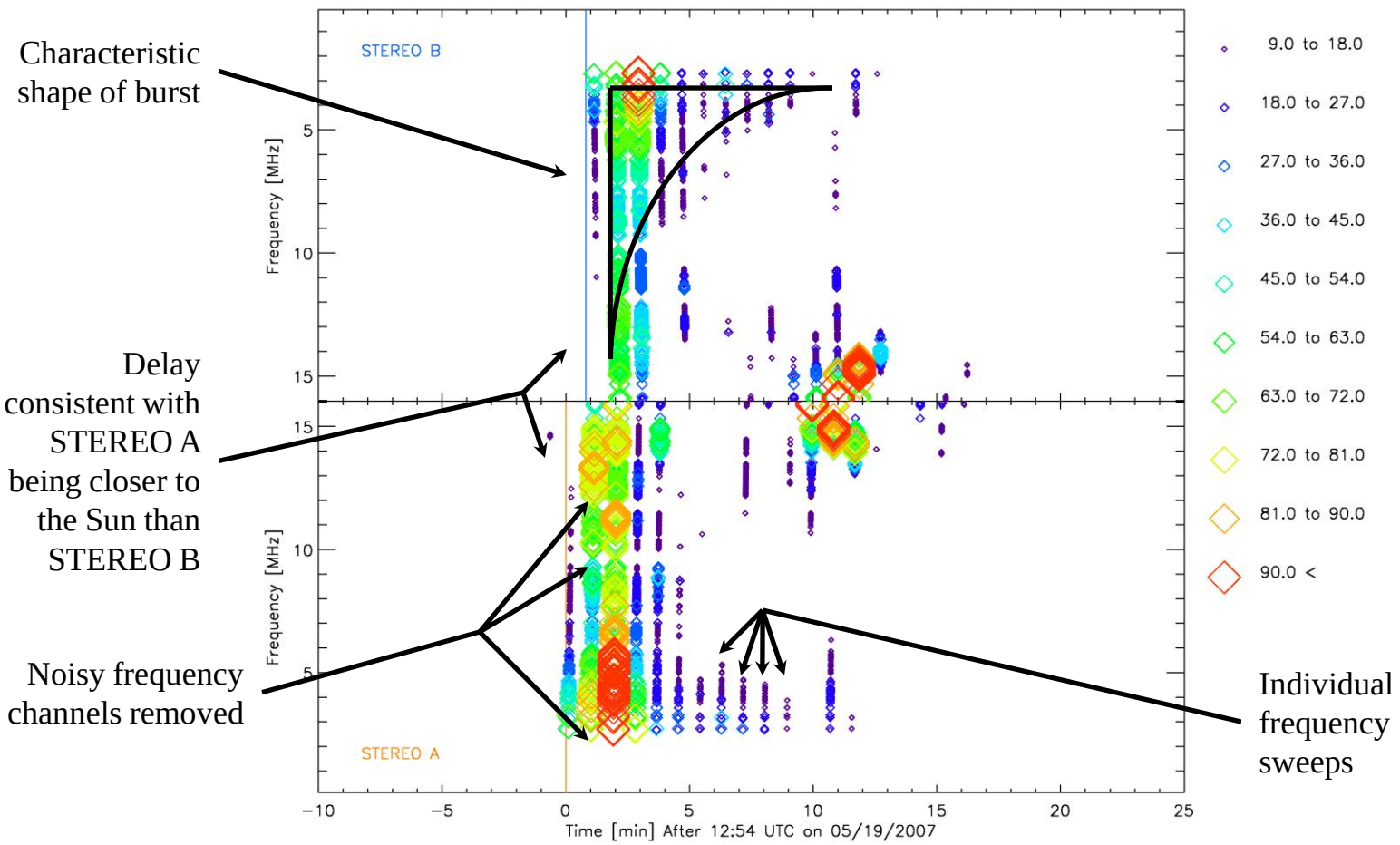
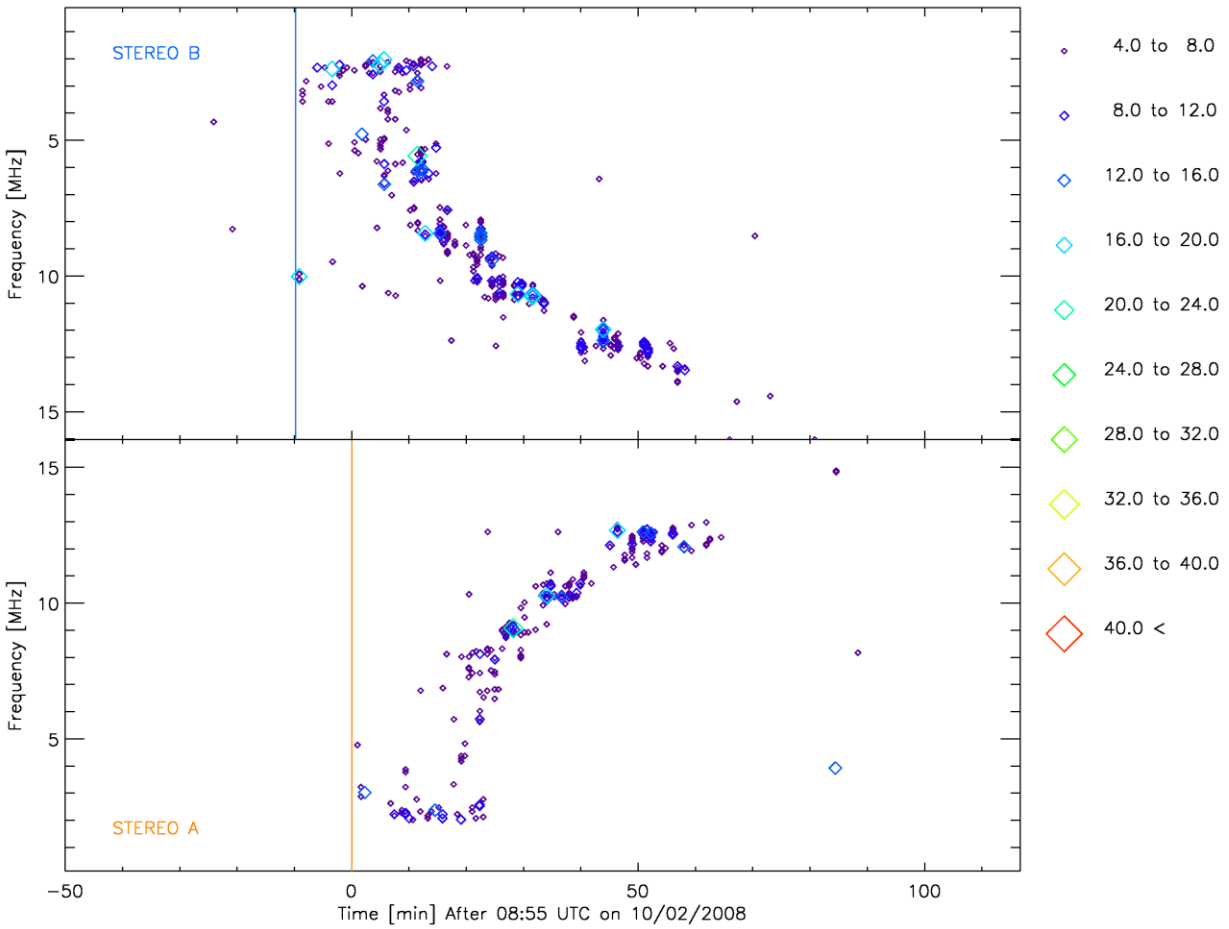
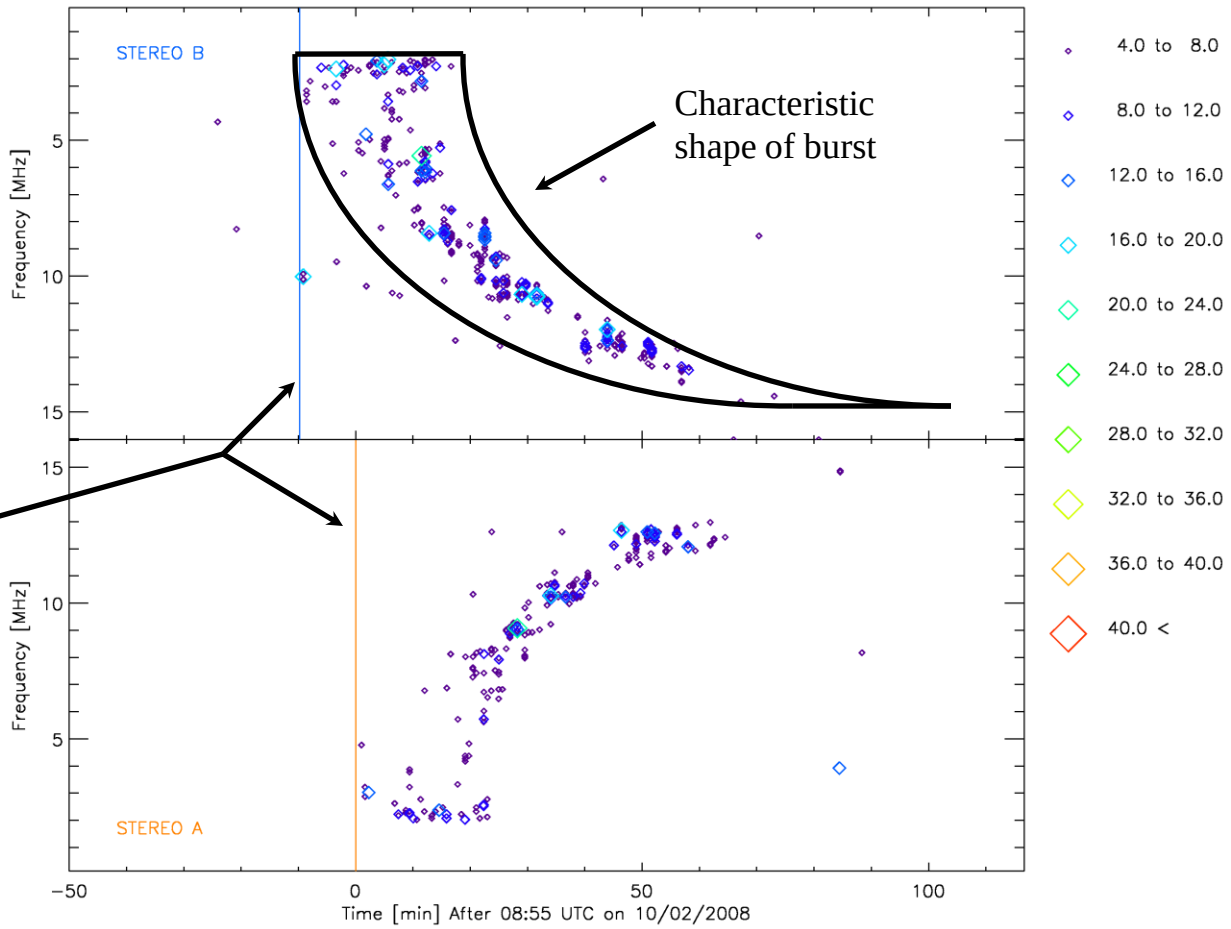


Jupiter-Io Burst (Type D)

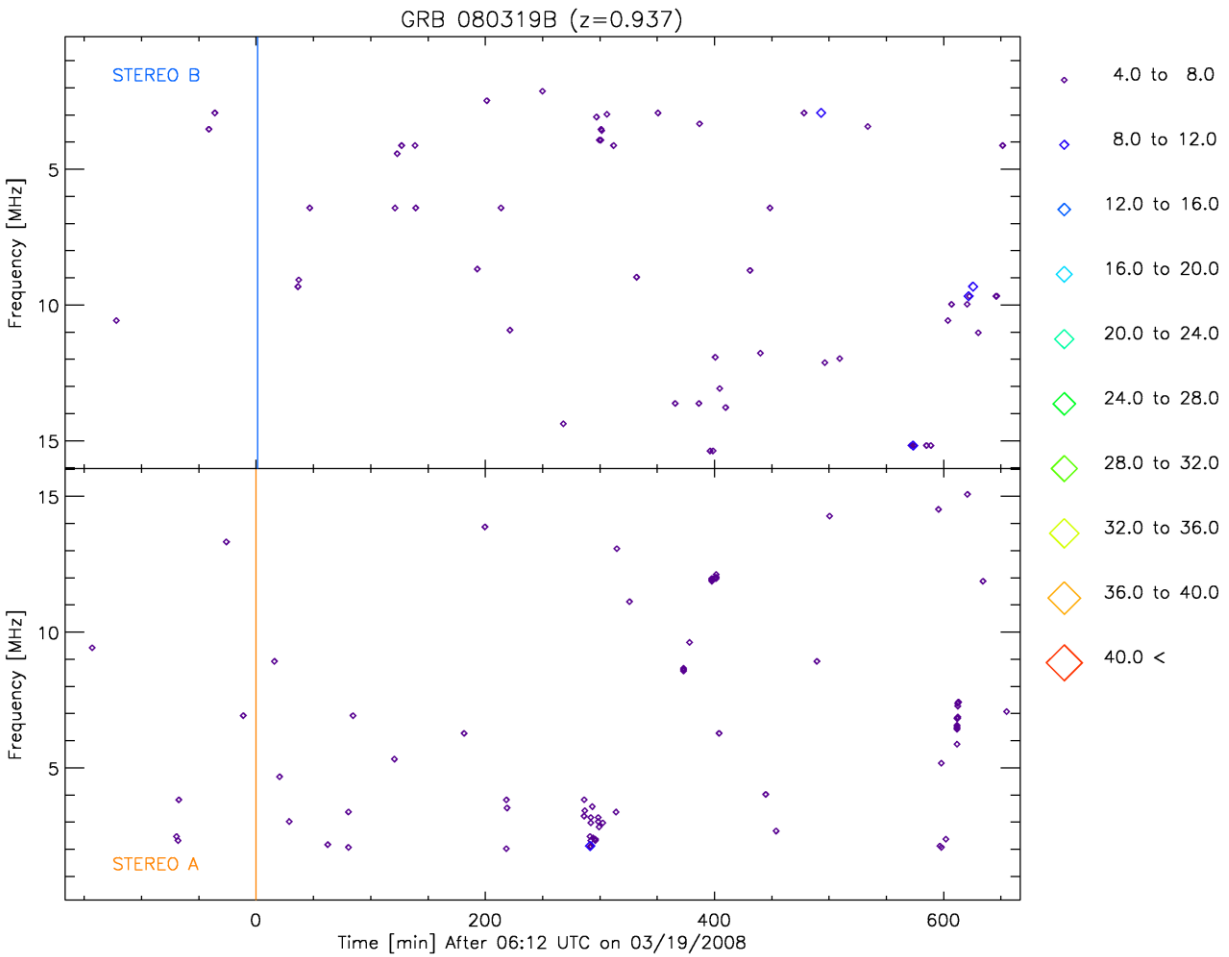


Jupiter-Io Burst (Type D)

Delay greater than light-travel time between spacecraft at time of observation



Gamma-Ray Burst (Null Result)



Conclusions

- Summary of progress
  - Development of code for calculating signal delays from various sources
  - Identification of Solar and Jovian radio bursts
  - Null result for detection of extra-solar bursts (i.e., from Sag A* and GRB's)
- Current lines of investigation
  - Calculation of upper bounds on decameter emissions from GRB's
  - Statistical analysis to search for frequent but weak events (e.g., from Sag A*)
  - Rigorous measurements of signal delays (versus just consistency checks)
  - Automatic identification of events